Physiologic Specialization and Sources of Resistance to Wheat Leaf Rust in Kenya

D. E. Harder

Assistant Professor, University of Manitoba, Canada Department of Agriculture, 25 Dafoe Road, Winnipeg 19, Manitoba.

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ABSTRACT

Leaf rust of wheat is widespread in the low- to middle-altitude wheat-growing areas of Kenya. Two distinct physiologic races were identified using host differentials suited to the local leaf rust population. Race EAL 1 predominated, and together with EAL 2 comprised all the virulence found in leaf rust in Kenya. Most of the commonly used Kenya wheat cultivars are susceptible to one or both of the dominant races, but some excellent sources of resistance are available. Phytopathology 61:1201-1204.

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Leaf rust of wheat, *Puccinia recondita* Rob. ex Desm., is widespread in Kenya at elevations between 1,900 and 2,300 m, and may cause yield reductions of 20%.

There are no records of leaf rust investigations in Kenya; thus, little is known about the range of virulence and sources of resistance. Although selection for leaf rust resistance is a factor in the wheat-breeding program at the Plant Breeding Station, Njoro, the incorporation of leaf rust resistance has not been a primary objective because of the greater importance of wheat stem rust (3).

The present investigation was undertaken to study the virulence of leaf rust in Kenya, to find host cultivars suitable for differentiating races, and to locate sources of resistance.

MATERIALS AND METHODS.—During 1968-69, leaf rust was collected in all wheat-growing areas of Kenya. Urediospores were scraped from infected leaves with a sterile scalpel and transferred to the susceptible cultivar Florence Aurore for increase. The urediospores were then suspended in a light paraffin oil, Mobilsol 100, and sprayed onto seedling test plants. The inoculated plants were incubated for 24 hr in a polythene chamber under high humidity, then placed on benches in a shaded greenhouse with a maximum temperature of 22 C. Infection types (7) were scored about 14 days after inoculation.

The wheat cultivars used included those commonly grown in Kenya, those used as sources of stem rust resistance in the breeding program, lines of Thatcher or Prelude carrying substituted genes for leaf rust resistance, and "standard" leaf rust differentials (5). These were initially inoculated with 75 field-collected leaf rust samples to find differentiating hosts and to separate possible races. From this and subsequent tests with 80 additional collections, 8 cultivars (Table 1) were selected as potentially useful differentials. Twenty of the 155 field collections were mixtures of two races, giving a total of 175 isolates. All collections or isolates which appeared to be a new race were purified by single pustule isolation and were tested at least 2 more times on the differential hosts.

The leaf rust races were given an East African leaf rust (EAL) designation, using the virulence formula system developed for wheat stem rust by Green (2).

RESULTS.—Two races, EAL 1 and EAL 2, were clearly distinguished from 175 isolates using locally adapted wheat differentials (Table 1). Several other isolates, designated as EAL 1A, EAL 1B, and EAL 1C, were similar to EAL 1, but showed minor and variable differences in virulence; hence they are not now considered distinct races. In tests using a wide range of host resistance genotypes, races EAL 1 and EAL 2 comprised all of the virulence found in leaf rust in Kenya (Tables 1, 2). Of all isolates, 83% were EAL 1, 11% were EAL 2, and 6% were EAL 1A, EAL 1B, and EAL 1C.

Variable infection types were produced by the EAL races on some of the standard leaf rust differentials (Table 2-A) and some cultivars with substituted genes for leaf rust resistance (Table 2-B); hence these were not reliable differentials under Njoro conditions. Of the substituted single gene lines, those carrying *Lr 10*, *Lr 17*, and *Lr 18* are susceptible to all isolates, while

TABLE 1. East African leaf rust races, their virulence formulae, "standard" race equivalents, and number of isolates in Kenya in 1968 and 1969

Race designation	Virulence formula,[a] resistant/susceptible	Standard race number	No. isolates
EAL 1	1 2 3 8/4 5 6 7	127	145
EAL 1A	1 2 5 6 8/3 4 7		5
EAL 1B	1 2 3 7 8/4 5 6		3
EAL 1C	1 2 6 8/3 4 5 7		2
EAL 2	4 5 6 7/1 2 3 8	147	20

[a] Cultivars: 1 = Thatcher^6 × Centenario (Lr 1); 2 = T^7 × Webster (Lr 2); 3 = Prelude^6 × Loros (Lr 24); 4 = T^6 × Democrat (Lr 3); 5 = T^6 × Exchange (Lr 16); 6 = Kenya Kanga (a new Kenya variety, genotype unknown); 7 = Carina; 8 = Hussar.

TABLE 2. Infection types[a] produced by East Africa leaf rust races on seedlings of **A)** internationally used leaf rust differentials; **B)** lines of Thatcher or Prelude with substituted genes for leaf rust resistance; **C)** wheat cultivars commonly grown in Kenya; **D)** selected cultivars resistant to the East African leaf rust races

Cultivar	Known genotype	East African leaf rust race				
		EAL 1	EAL 1A	EAL 1B	EAL 1C	EAL 2
A						
Malakof	*Lr 1*	;	;	;	;	3+
Mediterranean	*Lr 3* plus . .	3+	3+	3+	3+	;
Hussar	*Lr 11*	13−	12	12	12	3+
Democrat	*Lr 3*	3+	3+	3+	3+	;1
Carina	$Lr\,2^2$	3	3	23	3	23−
Brevit	$Lr\,2^3$	3+	3	2	3	3
Webster	*Lr 2*	23−	23−	;2	23−	3+
Loros	$Lr\,2^4$	13−	3	23	3	3+
B						
T^6 × Centenario	*Lr 1*	;	;	;	;	3+
T^7 × Webster	*Lr 2*	23	23−	;2	22+	3+
P^6 × Loros	$Lr\,2^4$	23	3	23−	3	3+
T^6 × Democrat	*Lr 3*	3+	3+	3+	3+	;
T^6 × Exchange L3	*Lr 10*	3+	3+	3+	3+	3+
T^6 × Aniversario	*Lr 3* allele?	2	22+	23−	2	13−
T^7 × Bage	*Lr 3*?	3+	3+	3+	3+	;
T^6 × Exchange E1	*Lr 16*	3+	2±	3	3	22+
T^6 × Klein Lucero	*Lr 17*	3+	3+	3+	3+	3+
T^6 × Africa 43	*Lr 18*	3+	3+	3+	3+	3+
T^6 × Transfer	*Lr 9*	;	;	;	;	;
C						
Africa Mayo		3+	3+	3+	3+	3+
Trophy		3+	12	3	12	3
Kenya Kudu		3	3	12+	3−3	3
Kenya Page		2±	12	23−	;2	3
Kenya Hunter		3	23	3	2±	3
Bounty		3+	12	3−3	12	23−
Kenya Sungura		3	3+	3	3−3	3
Kenya Leopard		3	3+	3	;2	3+
Token		3	23	3	12+	3
Africa 43		3+	13	3−3	12+	3
Yaktana		3	12+	23−	3−	23−
Wisconsin Supremo		3	12	3−3	3−3	3+
Kenya Grange		3	3	3	3	3
Fronthatch		23−	13−	;2	;1+	23−
Fanfare		3+	3		;3−	3
Bonny		3	12	3	;2+	
Kenya Plume		3−	;1	12+	;2	3
Kenya Twiga		;2[c]	;3−	12+	;2	3−
Tai[b]		3	3	23−	3−	2±
Kasuku[b]		3	3	23−	3−	13
Romany		;1[cn]	;1[c]	;1[cn]	;[c]	;2[cn]
Tobari 66		;	;	;	;	12+
Kenya Kanga		3+	;2+	3	;2+	23−
C.I. 8154 × $Frocor^2$		3	3			23−
D						
Frontana	*Lr 13*[c] plus . .	3+	1	23−	2	13−
Agatha	*Lr 19*[d]	;	;	;	;	;1
Agent[d]		;	;	;	;	;
Transec[e]		;	;	;	;	;
Transfer[f]		;	;	;	;	;
Dular[g]		;1	;1	;1	;1	;1
Wardal[g]		;	;	;	;	3+
Purdue 5396[g]		;	;	;	;	;
Pawnee × (Chin.-*Aegellops umbellulata*)[g]		;	;	;	;	;
Triticum speltoides amp. × Supremo[g]		12	23−	;1+	;1+	1
$Ponca^2$ × Aniversario[g]		;1−	12−	;1	;1	;
Lee × $Frontana^2$ × Crr.[g]		3−	3−	;2+	23−	;3−
Kenya Farmer Hope		12	12	;2	3−	23

TABLE 2. (*Continued*)

Cultivar	Known genotype	East African leaf rust race				
		EAL 1	EAL 1A	EAL 1B	EAL 1C	EAL 2
D (*Cont.*)						
Transfer³ × wheat × rye² × TW815-X-2, Tifton 2892[g]		;	;	;	;	;
C.I. 12034² × Comanchee × Pawnee³ × Concho[g]		;	;	;	;	;
Purdue 6234 composite[g]		;	;	;	;	;
Preska OK 14153[g]		;	;	;	;	;
Timpaw OK 14154[g]		;	;	;	;	;
Rio Negro × Comanche[g]		;1+	2	12+	12	;2
Kanred × Hard Federation[g]		;	;	;	;	;
Aurora[g]		;	;	;	;	;
Kavkaz[g]		;	;	;	;	;
Dimitrovka		3	;1	2	;1	13
Chris		3—	3—	23—	3—	23—
II-62-16		12	13—	3	12	13—
Pb⁶-Tf × Pb⁶-Sr8		;	;	;	;	;
Thatcher backcross RL 4203		;	;	;	;	;1
Penjamo 62 × Gabo² × Tz PP × Knott × 2, II-18717 3M-2y-5M-1y-6c		;	;	;	;	;
ND 76 × Conley², 65-12-83		;	;	;	;	;
Lee		23—	2			;1
Lee-Mida-Bonza²		13—	;2+			;2+
SRPC 408/67		;2	;2+			;1
CD 1141/A.2		;	;			;
1044 A.I.A. 4		3	13—			;1+
Wisconsin 245-II-50-17		23	;2			;1—
Minnesota 3654/60		;	;			;1—
SRPC 527/67[h]		12cn	23—cn			;1cn

[a] Resistant (; to 1), moderate resistant (2), moderate susceptible (3), and susceptible (4). Infections somewhat greater than the "type" are indicated by +, and those somewhat less by —. Combined types, e.g. 13, indicate the range of infection types (1 to 3) produced by a single race on a given cultivar.
[b] Durums.
[c] Conditions adult-type resistance.
[d] *Agropyron elongatum* derivative.
[e] Wheat-rye translocation.
[f] *Aegellops umbellulata* derivative.
[g] Winter-type cultivars.
[h] *Aegellops speltoides* and *Ae. ovata* derivative, may also carry resistance from *Agropyron*.

only the Thatcher lines carrying either *Lr 9* or a gene(s) from Aniversario are resistant to all isolates.

Most of the cultivars which have been commonly grown in Kenya are not resistant to races EAL 1 or EAL 2 (Table 2-C). Africa Mayo and Trophy are among the most widely grown wheat cultivars in Kenya, but are susceptible as seedlings and in the field. The cultivars Fronthatch, Kenya Kanga Romany, and Tobari 66 have adequate resistance, but only Fronthatch and Kenya Kanga are presently grown by Kenya farmers. However, Romany and Tobari 66 are recurrent parents in a backcross breeding program at Njoro (4), and should provide important leaf rust resistance.

There is a good reservoir of resistance effective against the EAL races (Table 2-D). The pedigrees [see Evans et al. (1) for parentage of cultivars listed from Lee-Mida-Bonza² to SRPC 527/67] suggest a wide diversity of resistance. Frontana has provided important adult-type resistance throughout the world, and all cultivars in the International Spring Wheat Rust Nursery that have Frontana in their parentage have field resistance to leaf rust in Kenya. This cultivar also has additional seedling resistance in Kenya. All cultivars which have interspecific or intergeneric translocations in their parentage are highly resistant as seedlings, although Transfer is moderately susceptible in the field. The cultivars Dular to Kavkaz (Table 2-D), although they are of winter habit, may provide a useful pool of resistance. The cultivars Lee-Mida-Bonza² to SRPC 527/67 (Table 2-D) are currently being used as sources of stem rust resistance at Njoro (1), and may provide immediately useful leaf rust resistance.

DISCUSSION.—Since the wheat cultivars commonly grown in Kenya have little leaf rust resistance, it may be surmised that there has been little selective pressure for new leaf rust virulence. This may be responsible for the presence of only two significantly different patterns of virulence in the pathogen population, and for their predominance. The predominance of EAL 1 may be due to an environmental-adaptive advantage. The races that have been identified are from a limited number of collections, and more sampling may reveal additional virulence. Also, as more resistant material is introduced, the pattern of virulence in leaf rust may well change.

The objective of this investigation was to provide a description of leaf rust virulence that is meaningful in terms of the breeding program at Njoro; hence, where possible, single gene lines were used as differentials. This provides a direct genetic basis for describing leaf rust virulence, and makes possible a more meaningful selection of resistance sources. In this regard EAL 1 and EAL 2 together comprise all of the virulence so far seen, and any combination of *Lr 1* and *Lr 3* would provide adequate resistance. If new virulence is found, a wide range of resistance sources is available.

Although the genotypes of those cultivars suggested as sources of resistance are largely unknown, combinations of known resistance genes could account for the patterns of resistance. Any combination of *Lr 1*, *Lr 3*, or a translocation gene would condition a (;) or (;1) infection type. Cultivars such as SRPC 408/67 and Wisc. 245-II-50-17 may carry *Lr 3* plus one or more of the genes conditioning an intermediate-type reaction, whereas Tobari 66, which behaves in the opposite fashion, may carry *Lr 1* plus a gene(s) conditioning an intermediate-type reaction.

Some comparison may be made between the Kenyan and North American leaf rust populations. Samborski (6) showed the number of 1969 leaf rust isolates in Canada that show virulence or avirulence on a number of lines with substituted genes for leaf rust resistance. The large majority of isolates were avirulent on lines with *Lr 10*, *Lr 16*, *Lr 17*, and *Lr 18*. In Kenya, all isolates were virulent on lines with *Lr 10*, *Lr 17*, and *Lr 18*, and most isolates were virulent on the line with *Lr 16*. The resistance conferred by genes *Lr 1*, *Lr 2*, and *Lr 3* followed similar patterns in Kenya and Canada. These results indicate some difference in the evolutionary development in leaf rust between these two widely divergent areas.

LITERATURE CITED

1. Evans, L. E., J. W. Martens, G. J. Green, & E. A. Hurd. 1969. Sources of resistance to wheat stem rust in East Africa. Can. J. Plant Sci. 49:649-654.
2. Green, G. J. 1965. Stem rust of wheat, rye and barley in Canada in 1964. Can. Plant Dis. Surv. 45:23-29.
3. Green, G. J., J. W. Martens, & O. Ribeiro. 1970. Epidemiology and specialization of wheat and oat stem rusts in Kenya in 1968. Phytopathology 60: 309-314.
4. Hurd, E. A., M. W. Oggema, & L. E. Evans. 1969. New emphasis on wheat breeding in Kenya. East Afr. Agr. Forest. J. 35:213-216.
5. Johnston, C. O., & L. E. Browder. 1966. Seventh revision of the international register of physiologic races of Puccinia recondita f. sp. tritici. Plant Dis. Reptr. 50:756-760.
6. Samborski, D. J. 1969. Leaf rust of wheat in Canada in 1969. Can. Plant Dis. Surv. 49:80-82.
7. Stakman, E. C., D. M. Stewart, & W. Q. Loegering. 1962. Identification of races of Puccinia graminis var. tritici. USDA Agr. Res. Serv. E617 (revised 1962). 53 p.